Chemical inhomogenities in Py/Cu GMR multilayers analyzed by μ-NEXAFS microscopy at beamline 6.3.2

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INTRODUCTION

The structural and chemical properties of magnetic multilayer systems for Giant Magnetoresistance (GMR) applications significantly influence the amplitude of the GMR effect.

While many publications deal with a structural characterization of the multilayers e.g. by means of x-ray diffraction or cross-sectional Transmission Electron Microscopy to reveal layer thickness and interfacial roughness data, only very few publications deal with the chemical composition and especially microscopic chemical inhomogenities and layer defects which may occur on the surface and inside the samples.

First data about microscopic surface defects and inhomogenities in Copper-Permalloy multilayers, as measured by microspot NEXAFS-microscopy at the ALS bending magnet beamline 6.3.2, are presented in this paper.

EXPERIMENTAL DETAILS

Copper-Permalloy $(Cu/Fe_{81}Ni_{19})_{40}$ multilayer samples (terminating layer permalloy) were prepared by d.c. magnetron sputtering onto permalloy-buffered glass substrates at different deposition parameters (details about the deposition process are described in Ref. 1).

The samples were analyzed in a scanning microspot NEXAFS-microscope setup at beamline 6.3.2 (details of the micro-NEXAFS setup are described in Ref. 2).

A 5 *15 μm^2 pinhole positioned in the center of a reflectometer chamber at beamline 6.3.2 and illuminated by monochromatic dipole radiation is demagnified by a Kirckpatrick-Baez (K-B) mirror system consisting of two elliptically bent Ni-coated silicon mirrors onto the sample plane. While the minimum spot size theoretically achievable is about 1 micron, the experimentally observed spot size was about 2 * 3 μm^2 limited by abberations of the K-B mirror system.

The sample is scanned by a x-y translation stage equipped with LVDT position encoders (maximum scan range 50 * 50 mm^2 with sub-micron position accuracy). Secondary electrons emitted from the sample are recorded by a Channel Electron Multiplier in a total yield mode.

RESULTS

Fig. 1 displays a typical total yield spectrum measured with a microspot in the 700-1000 eV energy range (linearly polarized radiation) at an arbitrary sample position of a Cu/Py multilayer sample.

The spectrum clearly displays the Fe-$L_{2/3}$ absorption edge at 721 eV / 710 eV and the corresponding Ni-$L_{2/3}$ edge at 871 eV / 854 eV, both edges corresponding to the permalloy surface layer. Only very little contribution from the buried copper layer can be found at 953 eV / 933 eV (Cu-$L_{2/3}$) due to the surface sensitivity of the total yield absorption measurement.

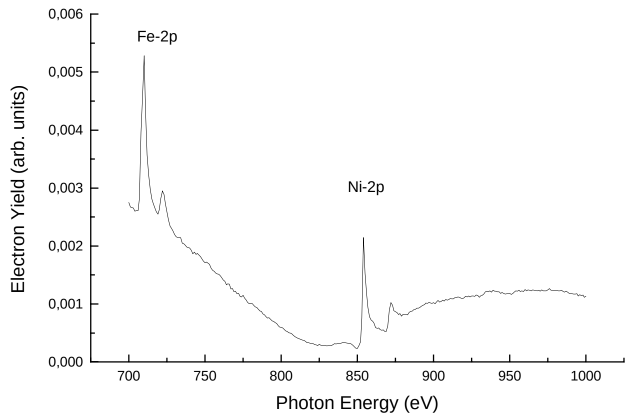

Fig. 1 : Total electron yield microspot absorption measurement on a Cu/Py multilayer sample

A microscopic image of the iron distribution was recorded by scanning a 500 * 500 μm^2 area of the sample (step size 10 micron) at 710 eV photon energy. The image (Fig. 2) shows a constant total yield signal over large areas of the sample surface and some isolated defects as displayed by a reduced total yield signal.

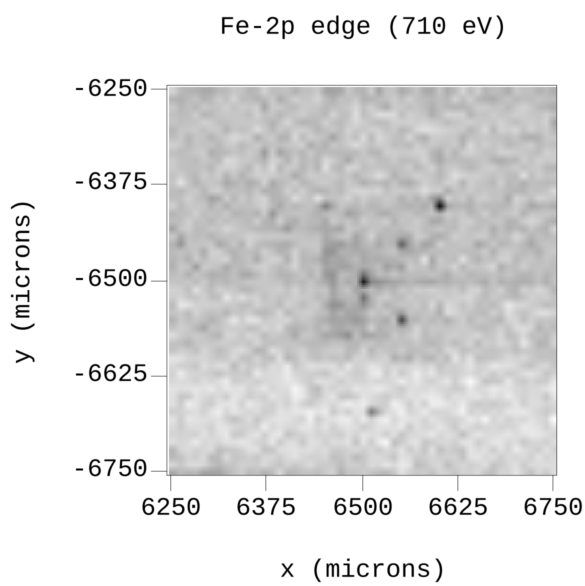

Fig. 2 : Micro-NEXAFS image (500 *500 μm^2 scan field) at 710 eV photon energy (step size 10 micron)

Two more detailed zoom images of a 200 * 200 μm^2 scan field (4 micron step size) recorded at two different energies (710 eV and 854 eV) show that the defects are only visible at the Fe-2p edge (Fig. 3a) while they vanish at the Ni-2p edge (Fig. 3b).
These results clearly indicate that this type of defects mainly influences the iron signal in the permalloy alloy while the nickel signal remains almost unchanged. This cannot be explained by a simple topographic defect in the permalloy layer, where both signals should be affected. A possible explanation can be given by assuming a local segregation of surface alloy layer which may occur as a result of an oxidation process of the topmost permalloy layer.
This interpretation is also supported by further measurements performed at the O-K edge (not shown).

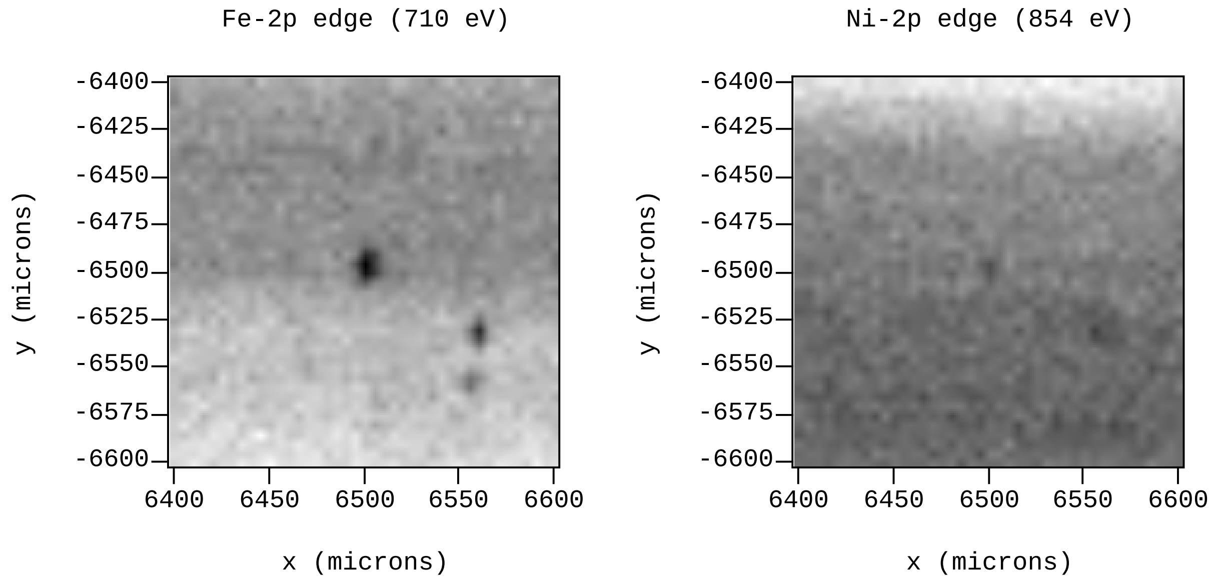

Fig. 3 a, b : Micro-NEXAFS images of surface defects at 710 eV (a) and 854 eV(b) photon energy

CONCLUSIONS

We have studied chemical inhomogenities in Cu/Py multilayers on a microscopic scale by using micro-NEXAFS microscopy at beamline 6.3.2.

Several defects in the iron distribution of the top permalloy layer could be found which did not show up in the corresponding nickel distribution. A more thorough understanding of defects and inhomogenities in GMR multilayer systems is especially important for improving the lifetime stability of devices based on these systems.

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